

ERGONOMIC JOB REDESIGN FOR MULTITASK PACKAGING WORK BY
USING REVISED NIOSH LIFTING EQUATION

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DEDICATION

To mama and abah

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ABSTRACT

The purpose of this study is to analyze the existing operation of a manual multitask packaging work task which is hazardous to a worker and then suggest the improvements by providing practical guidelines ergonomically. The work task was suggested to be redesigned ergonomically and improved by looking for clues and reviewing previous complaints, by observing the work activities, and by talking to the workers, supervisors, and managers. Several National Institute for Occupational Safety and Health (NIOSH) assessment tools of assessing work task was conducted to quickly detect problem work tasks. The result of the analysis did show that the evaluated work task is physically stressful to even healthy workers but follow up actions were not done because the suggested improvements were not accepted and implemented. Despite the fact that the suggested improvements were not accepted, the ergonomic practical guidelines were still established generally and may only be reliable if were to be used in the evaluated section of BI Technologies Corporation Sdn. Bhd.

ABSTRAK

Tujuan pengkajian ini adalah untuk menganalisa operasi sejumlah kerja-kerja membungkus secara manual yang berbahaya bagi pekerja dan mencadangkan perbaikan dengan menyediakan pengarahannya praktikal secara ergonomik. Tugas kerja telah dicadangkan untuk dicorak secara ergonomik dan diperbaiki dengan mencari tanda-tanda, meninjau kembali aduan-aduan yang terdahulu, memerhati aktiviti-aktiviti kerja, dan berbincang dengan pekerja, penyelia, dan pengurus. Beberapa kaedah pengkajian daripada Pengurusan Keselamatan dan Kesihatan Pekerjaan (NIOSH) telah digunakan untuk mengkaji tugas kerja bagi mengesan masalah tugas kerja dengan cepat. Keputusan bagi analisis menunjukkan tugas kerja yang telah dinilai adalah memberikan penekanan secara fizikal mahupun untuk pekerja yang sihat tetapi tindakan turutan tidak dilakukan kerana perbaikan yang dicadangkan tidak diterima, pengarahannya praktikal secara ergonomik tetap disediakan secara umum dan mungkin hanya akan boleh digunakan sekiranya dilaksanakan di bahagian Syarikat BI Technologies Sdn. Bhd. yang telah dinilai.

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LIST OF SYMBOLS

ml	Millilitre
kg	Kilogram
min	Minutes
°C	Degrees Celsius
°F	Degrees Fahrenheit

LIST OF ABBREVIATIONS

AM	Asymmetric Multiplier
C	Coupling Classification
CLI	Composite Lifting Index
CM	Coupling Multiplier
DM	Distance Multiplier
FILI	Frequency Independent Lifting Index
FIRWL	Frequency Independent Weight Limit
FM	Frequency Multiplier
HM	Horizontal Multiplier
L	Load Weight
LBP	Lower Back Pain
LC	Load Constant
LI	Lifting Index
MMH	Manual Material Handling
MSD	Musculoskeletal Disorder
NIOSH	National Institute of Occupational Safety and Health
RWL	Recommended Weight Limit
STLI	Single Task Lifting Index
STRWL	Single Task Recommended Weight Limit
VM	Vertical Multiplier

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Ergonomics is a discipline in the health and safety industry that study the human relation with equipments, machineries, procedures, and working environment. It concentrates on effort to optimize human ability with the job done (National Institute for Occupational Safety and Health (NIOSH, 2005). Ergonomics is frequently associated with manual material handling (MMH) (lifting, carrying, pushing, or pulling) which represents an occupational risk factor that has to be confined within safe limits (Cheung et. al., 2007).

Acute and chronic work-related injuries may be attributed to excessive force demanded by the task (Chung et. al., 1996). In this study, the literature revolves around the effects of body posture, reach distance, arm orientations, speed, and duration of exertions are the issues frequently mentioned. Some important background factors will be considered including age, height, weight, sex, number of working hours per week, working time with present work task, number of working task, and anthropometry data ranges based on participants.

Scientific evidence shows that effective ergonomic interventions can lower the physical demands of MMH work task, thereby lowering the incidence and severity of the musculoskeletal injuries they can cause (NIOSH, 2007). Their potential for reducing injury related costs alone makes ergonomic interventions a useful tool for improving a company's productivity, product quality, and overall business competitiveness.

But very often productivity gets an additional and solid shot in the arm when managers and workers take a fresh look at how best to use energy, equipment, and exertion to get the job done in the most efficient, effective, and effortless way possible. Planning that applies these principles can result in big wins for all concerned.

This study was conducted to help individuals recognize high risk MMH work tasks and choose effective options for reducing their physical demands. Also through out this study paper, approaches such as NIOSH MMH Checklist, NIOSH Hazard Evaluation Checklist For Lifting, Ergonomics Awareness Worksheet, and Ergonomic Checklist For Material Handling were used as assessment tools and briefly described. The Revised NIOSH Lifting Equation was used as the main analysis methods to find the level of hazard imposed by a specific work task which will later be discussed through out the voyage of this paper.

Improvements towards positive construction of the work task were done during the redesign phase of the study. The improvements were clearly and briefly explained. Their each own significant justification of why it should be implemented were also stated together with the suggestions. These improvements generally are of the engineering point of view rather than from administrative point of view.

1.2 PROBLEM STATEMENT

The BI Technologies (Magnetic Component Division) is having the problem of improving the fit between the demands of works tasks and the capabilities of their workers. The workers are exposed to risk factors for musculoskeletal disorders (MSD) due to awkward postures while working.

Problems of working methods that are potential to cause injuries are to be solved, prevented, or reduced to eliminate the problems regarding MSD as described previously.

1.3 OBJECTIVE

- 1.3.1** To analyze the existing operation of packaging work that is hazardous to a worker.
- 1.3.2** To suggest improvements by developing practical guidelines for ergonomic job redesign.

1.4 SCOPE OF STUDY

The scope of the study is the investigation of the current implementation of MMH in BI Technologies (Magnetic Component Division) at Jalan Tanjung Api, Kuantan. The evaluation will be done by using Revised NIOSH Lifting Equation. The evaluations will be limited to two-handed task only. The gender that is involved with this study is female. The improvements that ought to be made would probably fit only to BI Technologies and may not be applicable anywhere else.

1.5 OVERVIEW OF THE THESIS

From the literature review done, important information was extracted and combined to create a hypothesis concerning ergonomic job redesign for a manual material handling task. It can be said that if ergonomic interventions and useful tools are used to improve the work task that are considered as hazardous, then the severity of the MSD incidence could be lowered because effective ergonomic interventions can lower the demands of MMH and improving the fit between work tasks.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Manual material handling (MMH) activities are not a foreign issue in industrial jobs. MMH tasks such as manually lifting, lowering, pushing, pulling, or carrying an object are typical examples of the activities requiring human strength (Mital et al., 1999). Although countless jobs are becoming mechanized and automated, human strength is still required in many industrial activities (Chung et al., 1996). MMH is consistently recognized as a major hazard in the workplace (Marley et al., 1996). It is also frequently associated with numerous risks of injuries (Godwin et al., 2007) and have been discussed in ergonomics and other related realms for a long period of time due to the fact that they are known to be one of the main causes of musculoskeletal overexertion injuries (Chung et al., 1996). The accumulated fatigue is the cause for degraded performance in the musculoskeletal system, which is one of the distinguishing physiological characteristics (or symptoms) of the human worker.

Nearly every tasks of MMH requires repetitive dynamic force exertions. It can be hypothesized that repetitive force exertions also lead to physiological fatigue, although it is known that static tasks are more problematic (Chung et al., 1996). The prevention of overexertion injuries and those other muscle exertion while performing manual tasks can be done by investigating the implications of various tasks variable on muscle strength, applying appropriate correction factors for specific task conditions (Chung et al., 1996), and by having adequate postural stability (Holbein et al., 1997). Therefore, every effort should be made to improve working conditions within this field of activities. There is a need for recounting the ergonomic evaluation

to the specific occurrences or tasks performed in the field of work. It may be significant in the analysis practice to identify particularly strenuous tasks, as a basis for interventions, or the mix of high and low load periods (Forsman et al., 1999).

2.2 MANUAL MATERIAL HANDLING CRITERIA

The most commonly used MMH criteria will be discussed briefly below. For a more detailed discussion of MMH criteria, the interested reader is referred to Dempsey (1999).

2.2.1 Biomechanical Criteria

Biomechanical criteria are related to limiting external or internal forces to levels that do not exceed the musculoskeletal system capacity. Joint and composite strengths can be compared to strength required to perform a task, whereas tissue limits can be compared to shear and compressive forces acting on intervertebral discs. Biomechanical models of the low-back are used to estimate the shear and compressive forces acting upon the spine, particularly the L5/S1 joint. Although shear forces are often estimated, the author is aware of only one epidemiological study incorporating shear loading as an exposure determinant. The most common spinal compression criterion is the 3400 N peak limit suggested by NIOSH (1981), although alternate values have been suggested (Jäger and Luttman, 1997). Jäger and Luttman (1997) recommended incorporating age and gender as important factors when setting a criterion. Lumbosacral compression is the most commonly used biomechanical criterion.

2.2.2 Physiological Criteria

Physiological criteria focus on limiting energy expenditure to levels that do not result in excessive whole-body or localized fatigue. The level of acceptable energy expenditure is dependent upon the duration of the task, as acceptable energy expenditure and task duration are inversely related. Physiological criteria apply to repetitive task performed continuously. Heart rate, rate of oxygen consumption (or

the equivalent energy expenditure), and percentage of maximum oxygen uptake can potentially be used as criteria. It should be noted that physiological criteria have not shown much promise with regards to differentiating the low-back disorder risk of different work designs (Dempsey, 1998; Leamon, 1994); thus, their use as exposure measures may be limited. The rate of oxygen consumption is the most common measure of energy expenditure. Often, a rate is chosen that corresponds to a majority of the population being accommodated. Oxygen consumption can be expressed in absolute terms (ml/kg/min or ml/min) or in relative terms (percent of maximum oxygen uptake). A criterion of one liter of oxygen per minute has historically been the most commonly used physiological criterion, although recent NIOSH guidelines (Waters et al., 1993) used more conservative values.

2.2.3 Psychophysical Criteria

The most commonly used psychophysical criterion is the percentage of the population (male, female, or combined) that a task accommodates with respect to weight or force values found in tables of psychophysical data. The largest and most comprehensive single set of tables can be found in Snook and Ciriello (1991). A criterion that at least 75% of workers are accommodated has been suggested (Snook, 1978; Snook et al., 1978). In some more cases, more conservative values are used (Waters et al., 1993).

2.2.4 Composite Criteria

The term composite criterion refers to those criteria that are developed from two or more of the individual criteria discussed above. One of the most widely recognized composite criterion is the 1991 NIOSH lifting equation (Waters et al., 1993), which incorporates biomechanical, psychophysical, and physiological criteria. Another example is the guidelines developed by Mital et al. (1997). In general, guidelines such as these attempts to satisfy criteria based upon multiple approaches. These methods provide a common exposure metric for multiple criteria.

2.3 ERGONOMIC IMPROVEMENTS

In general, ergonomic improvements are changes made to improve the fit between demands of work tasks and the capabilities of your workers. There are usually many options for improving a particular manual handling task. It is crucial to make choices regarding which improvements will work best for a particular task. For a more brief explanation, interested readers should refer to NIOSH Ergonomic Guidelines for Manual Material Handling (2007). There are two types of ergonomic improvements:

2.3.1 Engineering Improvements

Engineering improvements include rearranging, modifying, redesigning, providing or replacing tools, equipment, workstations, packaging, parts, processes, products, or materials.

2.3.2 Administrative Improvements

Administrative improvements would consider alternating heavy tasks with light task, provide variety in jobs to eliminate or reduce repetition (overuse of the same muscle group), adjust work schedules, work pace, or work practices, provide recovery time (short rest breaks), modify work practices within power zone (above the knees, below the shoulder, close to the body), and rotate workers through jobs that uses different muscles, body parts, or postures. Administrative improvements, such as, job rotation, can help reduce workers' exposures to risk factors by limiting to the amount of time workers spend on "problem jobs". However, these measures may still expose workers to risk factors that can lead to injuries. For these reasons, the most effective way to eliminate "problem jobs" is to change them. This can be done by putting into place the appropriate engineering improvements and modifying work practices accordingly.

2.3.3 Training

Training alone is not an ergonomic improvement. Instead, it should be used together with any workplace changes made. Workers need training and hands-on practice with new tools, equipment, or work practices to make sure they have the skills necessary to work safely. Training is most effective when it is interactive and fully involves workers.

2.3.4 Improvement Options

As improvement options are evaluated previously, several crucial requirements need to be taken into consideration for the particular workplace of interest. Those improvements that need to be done need to be asked general questions such as below. Will this improvement:

- (i) Reduce or eliminate most or all of the identified risk factors?
- (ii) Add any new risk factors that have not been previously identified?
- (iii) Be affordable for organization (e.g., simpler, inexpensive alternative that is equally effective)?
- (iv) Affect productivity or efficiency?
- (v) Affect product or service quality?
- (vi) Provide a temporary or permanent “fix”?
- (vii) Be accepted by employees?
- (viii) Affect employee morale?
- (ix) Be able to be fully implemented (including training) in a reasonable amount of time?
- (x) Affect the rate of pay or any collective bargaining elements?

2.4 DESIGN GUIDELINES FOR MANUAL MATERIAL HANDLING

Several different guidelines are available to design and/or analyze manual material handling tasks. Among the well-known guidelines are those proposed by NIOSH (1981; Waters et al.1993) and Mital et al. (1993, 1997). While the NIOSH

guidelines, both old and revised, are limited to manual lifting, the guidelines proposed by Mital et al. (1993,1997) extend to all kind of handling activities, including one-handed material handling activities (Mital et al., 1999). These various design guidelines will be applied throughout this study paper. The goal is to develop solutions or tool which can be used to analyze a specific task based on a well-defined task, including whole-body postures, locations and magnitudes of external loads, and worker characteristics (Holbein, 1997).

2.5 FACTORS AFFECTING HUMAN STRENGTH

A number personal and task factors influence human strengths were found based on Mital et. al. (1998). The factors that are particularly important are:

- (i) Age
- (ii) Gender
- (iii) Posture
- (iv) Reach distance
- (v) Arm and wrist orientations
- (vi) Speed of exertion
- (vii) Duration and frequency of operation

2.6 REVISED NIOSH LIFTING EQUATION

Several important equations were found based on Waters et. al. (1994). Only a few were described briefly below. Interested readers should refer to Waters et. al. (1994)

2.6.1 Recommended Weight Limit (*RWL*)

This is one of the principal products of the revised lifting equation. The *RWL* as shown in Equation 2.1 states that for a specific set of task conditions as the weight of the load that nearly all healthy workers could perform over a substantial period of time (e.g., up to 8 hours) without an increased risk in developing lifting-related lower

back pain (LBP). By defining healthy workers, it means that workers who are free from adverse health conditions that would increase their risk of having MSD. The equation for RWL is as stated below.

$$RWL = LC \times HM \times VM \times DM \times AM \times FM \times CM \quad (2.1)$$

Where;

LC	=	Load Constant
HM	=	Horizontal Multiplier
VM	=	Vertical Multiplier
DM	=	Distance Multiplier
AM	=	Asymmetric Multiplier
FM	=	Frequency Multiplier
CM	=	Coupling Multiplier

2.6.2 Lifting Index (LI)

The LI is a term that describes a relative estimate of the level of physical stress associated with a particular manual lifting task where L is the load weight. The estimate of the level of physical stress as shown in Equation 2.2 is defined by the relationship of the weight of the load lifted and the recommended weight limit.

$$LI = \frac{LoadWeight}{RecommendedWeightLimit} = \frac{L}{RWL} \quad (2.2)$$

2.7 TERMINOLOGY AND DATA DEFINITIONS

The following brief term definitions which are also based from Waters et. al. (1994) is useful in applying the NIOSH revised lifting equation. To have a clear view of the terms described below, refer to Fig. 2.1 and Fig. 2.2.

2.7.1 Lifting Task

Defined as the act of manually grasping an object of definable size and mass with two hands and vertically moving the object without mechanical assistance.

2.7.2 Load Weight (L)

Weight of the object to be lifted, in pounds or kilograms, including the container.

2.7.3 Horizontal Location (H)

Distance of the hand away from the mid-point between the ankles, in inches or centimeters (measured at the origin and destination of lift).

2.7.4 Vertical Location (V)

Distance of the hands above the floor, in inches or centimeters (measured at the origin or destination of lift).

2.7.5 Vertical Travel Distance (D)

Absolute value of the difference between the vertical heights at the destination and origin of the lift, in inches or centimeters.

2.7.6 Asymmetry Angle (A)

Angular measure of how far the object is displaced from the front (mid-sagittal plane) at the worker's body at the beginning or ending of the lift, in degrees (measure at the origin and destination of lift). The asymmetry angle is defined by the location of the load relative to the worker's mid-sagittal plane, as defined by the neutral body posture, rather than the position of the feet or the extent of body twist.